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Senate

THE ENERGY CONSERVING AUTOMATIC LIGHT OUTPUT SYSTEM

Mr. CURTIS. Mr. President, we know that conservation in conjunction with implementing improved technologies is an absolute necessity if the energy crisis is to be resolved. The administration claims to view the problem as analogous to war. Nevertheless, we do not seem to have the type of imagination and clear-headed direction that such a problem demands. In fact, in the absence of such direction, most agencies, companies, and individuals are still assessing the situation rather than taking coordinated positive action. There are new, exciting alternatives available to us, resulting from private initiatives, which demand immediate Government attention. As an example of what can be done, let me briefly comment on a recently developed lighting system technology which portends to save users up to 40 percent of the energy consumed in buildings throughout the United States.

The new system, named the energy conserving automatic light output (ECALO) system, accomplishes this without any reduction in the required lighting levels or undesired cosmetic effects. The significance of such a reduction offers a potential saving of 168 million barrels of oil per year which can be valued as high as $2 billion. The same saving expressed in nuclear energy terms would mean we would need over 100 less 1,000-megawatt nuclear powerplants.

The system was developed by Mr. Don F. Widmayer, who has been awarded a number of light control patents and is the president of Controlled Environment Systems, Inc., a research and development firm located in Rockville, Md. The system uses standard fluorescent lamps and ballasts making it suitable for utilization in existing lamp fixtures. In operation, the system automatically senses the room light level and adjusts the arc current downward to provide a constant predetermined light level for a given room or area. The so-called smart fixtures also take into consideration any increasing daylight in the room and proportionately adjust the manmade light down even further for a corresponding saving in energy. Further energy savings are made by virtue of having less heat due to lighting; the building, therefore, requires less air-conditioning during the critical summer months. Further details on this system and its economics are set forth in a report entitled "An Economic Analysis of the Energy Conserving Automatic Light Output (ECALO) System" authored by the staff and consultants of CESI.

It is conservatively estimated that the total energy savings would pay for these devices in 2 to 4 years, depending upon characteristics of the individual building. Each device can be installed in present fixtures in 5 to 15 minutes and are removable.

Now, I have no reason to promote this man, his company, or his ideas individually. What I am speaking of today is the slowness, the unconcern of the Washington bureaus, and the contempt they have for ideas that come from some place other than their own agency.

I would like to make special note of the fact that this system was not developed by big business or on Government contract. It was developed by a small business concern using its limited resources. For my part in encouraging such efforts, I am writing Secretary Schlesinger and GSA Administrator Solomon to request that they investigate the system for its energy-saving potential in Government buildings. It seems feasible that this system could be installed on a trial basis in one of the many Government buildings in Washington, D.C., to determine its merit. I believe prompt Government action will also encourage the private sector to take a closer look at such innovative approaches.

With further regard to the "ECALO" report, I ask unanimous consent that the report be printed in the RECORD for the benefit of my colleagues and others interested in energy conservation.

There being no objection, the material was ordered to be printed in the RECORD, as follows:

AN ECONOMIC ANALYSIS OF THE ENERGY CONSERVING AUTOMATIC LIGHT OUTPUT (ECALO) SYSTEM

PROPRIETARY NOTICE

The data furnished in this economic analysis of the ECALO System dated October 25, 1977, shall not be duplicated, used, or disclosed in whole or in part for any purpose other than to evaluate with a view towards entering into a license agreement or contract with Controlled Environment Systems, Inc. However, if a contract is awarded to Controlled Environment Systems, Inc. as a result of, or in connection with the submission of this data, the client shall have the right to duplicate, use or disclose the data to the extent provided in the contract.

1. BACKGROUND

Lighting accounts for one-fifth of all U.S. electric energy consumption and approximately 5% of fuel energy consumed. Since about two-thirds of lighting energy use is fluorescent and one-third incandescent, it becomes obvious that increased efficiency in fluorescent lighting energy use can significantly impact overall U.S. energy use.

For example, the adoption of a system which reduced the energy consumption of fluorescent lighting by 40% could result in annual savings to the U.S. of approximately 168 million barrels of oil,[1] savings which could translate into a reduction of U.S. oil imports amounting to $2 billion a year. Looked at another way, a 40% savings in fluorescent lighting energy could avoid the future construction of 100 to 150 1,000 MWe powerplants in the United States.[2]

2. OPPORTUNITY

The President and founder of CESI has developed an Energy Conserving Automatic Light Output (ECALO) System which promises the 40% overall savings in fluorescent lighting energy we mentioned above. This fluorescent lamp light feedback system automatically decreases lamp output (and electrical usage) with an increase in room light intensity from natural light. Likewise, the system will increase lamp output with a decrease in natural light in order to maintain a pre-set referenced or minimum level of illumination. By the automatic adjustment of the arc current, the system provides a control method for fluorescent light output.

The economic benefits realizable from the installation of the ECALO System come from three sources: (1) Lighting systems are typically designed with 25–40%[3] "excess" input energy to allow for degradation in light output due to maintenance factors and fluorescent bulb decay; (2) lighting systems are designed to produce recommended illumination levels regardless of external light

sources, hence do not fully utilize savings from direct or reflected sunlight; and (3) the vast majority of fluorescent lighting electrical usage is converted not into light, but heat. As a general rule, when air conditioning equipment is operating, each watt of lighting causes the expenditure of about one-half watt of air conditioning power. Thus, substantial cooling energy can be saved by reducing electrical light loads.[4]

Each of these three potential economic benefits will be dealt with in turn, but it is important to note that all three are "private" benefits accruing directly to the consumer (whether commercial or governmental) who installs the Energy Conserving Automatic Light Output System. There is also substantial "social" benefits or positive spill-over effects from the widespread installation of this system. These are benefits which would accrue to others not directly utilizing the system, and fall into two categories: (1) Reduction of the negative externalities associated with electrical power generation, such as patriculate and photo-chemical emissions from fossil fuel generation, heat and waste disposal from nuclear power plants, etc. and, (2) Alleviation of the peak load electrical power supply problem, which most often manifests itself as summer afternoon "brown outs".

As a rough example of a potential social benefit of this system, not captured by a direct user, consider the following situation: The Federal government owns or leases approximately 63 million square feet of office space in the Washington, D.C. metropolitan area.[5] If we assume the existing U.S. average electrical demand of approximately 2 We/sq. ft. for lighting[6] and postulate savings of 40% in lighting energy (.8 We/sq. ft.) with an associated savings of .4 We/sq. ft. in cooling energy on a summer afternoon, then the installation of this system in just U.S. Government offices would reduce peak electrical demand in the Washington area by 75,600 kW. This would free approximately 1½% of PEPCO's 1977 installed capacity for alternative uses[13].

3. SOURCES OF BENEFITS

A. Designed over-lighting

Architects, engineers and lighting systems designers are aware that fluorescent lamps—although four times as efficient as incandescent lamps[7]—suffer from decreased light output (lumens) per unit of electrical power consumption (watts) over time. The causes of this degradation are two-fold: (1) The collection of dust on lamps, fixtures, shields and/or lenses which tends to reduce illumination from a given lamp output, and (2) the decline of fluorescent lamps output caused by phosphor decay and the consumption of cathode material (lamp blackening). The absolute and relative amount of Lm/We degradation is very complex—depending upon factors such as ambient temperatures, drafts, frequency of cleaning and relamping, type of fixture, etc.—but can be seen in exhibit No. 1 shown on the next page. [EPRI Figure 12.2, page 672]

The economic significance of this is that since the lighting system must produce the desired level of illumination at the end of its life cycle, current technologies produce "too much" light during the life of the lamps with an accompanying excess use of electrical power. A comparison between current systems and the proposed ECALO system can be seen in exhibit No. 2.

Exhibit 2 is clearly meant to be illustrative in nature. The type of fixture, ambient temperature and dust levels, maintenance factors, etc. will yield different curves for different installations. Two items should be noted however: First, even after allowing for system degradation, much office space is over-lighted even at the end of the lamp life cycle. The ability of lighting systems, even after "quick and dirty" conservation measures, (such as removing alternate lamps) to produce adequate illumination levels speaks to this point. The Energy Conserving Automatic Light Output System allows for greater potential savings by setting predetermined reference level illumination standards below those now in effect. Secondly, the lumen-per-watt output relationship is not linear. Hence, a 50% reduction in wattage will reduce illumination by approximately 40%.

Controlled Environment Systems, Inc. estimates that for the standard four 40-watt lamp and ballast recessed fixtures found in many offices, the life cycle energy savings associated with the installation of the ECALO System would average 20%. Further economic benefits are realizable from: (a) Increased lamp life since lower wattage applied at the beginning of the lamp's life will retard phosphor decay and cathode material consumption, and (b) fewer fixtures and equipment will be required in new construction and renovations using the ECALO system since designed overlighting can be avoided. Further evidence and research is needed to estimate the magnitude of these savings.

B. Daylight usage

The primary uses of fluorescent lighting are offices, schools, commercial establishments and public buildings. In nearly every case there is available to at least part of the area, particularly during peak demand hours, a cheap and pollution free source of illumination—direct or reflected sunlight. Although buildings are occasionally designed to make use of natural light, one major drawback has been that since sunlight is an unreliable lighting source, electrical illumination must still be utilized. Given current lighting systems, in virtually all cases electrical/fluorescent lighting is supplied even when not needed to maintain desired illumination levels.

This situation arises because existing systems cannot easily or efficiently alter light output (or electrical power input) in response to changes in natural light. There are numerous reasons for this: Large general areas are frequently under the control of a single switch not permitting the turning off of lights in areas adjacent to windows; Frequent on-off use shortens lamp life; previous to the ECALO System the most reliable fluorescent lamp dimming systems used resistive elements and dissipated considerable energy as heat; certain lamps or fixtures have a warm-up period; and perhaps most importantly, it is awkward and (in real costs) expensive to interrupt work routines to adjust lighting levels to the time of day, cloud conditions, or other factors affecting natural light levels.

Despite these impediments, the Electric Power Research Institute cites increased use of natural light as the first "technological change" which could result in near-term improved energy efficiency in buildings.[8] The ECALO System promises the significant energy savings because, utilizing feedback mechanisms, the system will automatically and imperceptibly reduce fluorescent lamp output and energy usage with an increase in room light intensity.

Estimates of the energy savings from this source vary widely, depending upon a building's surface area, glass area and capacity, room cavity ratios, building orientation and shading, etc. For example, one-story buildings with undivided general areas, large windows and skylights could reasonably reduce daylight hour lighting energy demands by 80%, yet still have desired lighting levels regardless of the time of day or cloud conditions. Multi-level "cubic" office buildings would show lesser, but still significant, energy savings probably averaging 20%.

What is significant, and a point to which we will later return, is that these savings in electric power usage will be greatest at precisely the times when energy (¢/kwh) and demand charges ($/kwh) are highest, thus effecting even larger dollar savings.

C. Reduced cooling energy

As mentioned earlier, the Electric Power Research Institute estimates that each watt of lighting causes the expenditure of about one-half watt of air conditioning power when the air conditioning system is operating. This phenomenon arises because, even though flourescent lamps are the most efficient (in terms of Lm/We) source of office and commercial lighting, only 17 percent of the electrical energy is converted into light. The remainder of the energy is either radiated heat or heat dissipated through convection and conduction. The conventional ballast used in existing fluorescent fixtures accounts for a significant portion of that heat. Exhibit No. 3, shown on the next page, gives an indication of the sources and magnitude of lighting heat. [Figure 12.6, p. 687 of EPRI].

It must be noted that just as electric lighting places a sizeable demand on air conditioning equipment, the heat gain from lights can (and should) be included in the design of heating systems. Schemes utilizing waste heat from lights have emerged and newer building designs utilize this heat source. In general, however, lighting is a very inefficient heat source primarily because the heat is generated at the ceiling level (where it is not used) and much of it is trapped by the lighting fixture.

The significance of reduced cooling energy demands resulting in the installation of the Energy Conserving Automatic Light Output System is seen in an analysis of the shape of electrical energy demands for commercial and office buildings. A typical energy demand profile, shown in Exhibit No. 4, on the next page, [EPRI Figure 12.1, p. 660] reflects the fact that energy load composition tends to be principally lighting and environmental conditioning, with only 3 percent of electrical use devoted to vertical transportation, cooking, etc. Most significantly, above the level of demand for lighting the demand level for office buildings and commercial structures varies almost directly with outside temperature conditions[9].

Virtually all electric utility companies in the U.S. have higher energy charges and demand charges during the summer months. During these months the daylight period is longer, and the sun is brightest, allowing the ECALO System to minimize the use of electrical energy for lighting and at the same time, by reducing the heat from the lighting system, to minimize the electrical usage for air conditioning[10].

D. Externalities

It is not within the scope of this analysis to explore in detail the positive economic benefits accruing to society from the installation of the Energy Conserving Automatic Light Output System in commercial or governmental office buildings. The magnitude and distribution of these benefits will largely depend upon how widely the ECALO System is installed.

Few would deny, however, that the billed rate (¢/lwh) of electricity reflects the full social cost of electricity. The literature on negative externalities (pollution, etc.) of electric power generation, transmission and distribution, as well as other negative effects such as added oil imports—is extensive.

Similarly, the peak load problem of electric power generation is well known. While no one consumer can, by the installation of an ECALO System, significantly affect this problem, widespread installation could alleviate it in many areas of the country.

4. AN ILLUSTRATIVE ANALYSIS

It is the purpose of this section to present the results of four commonly used investment analysis techniques applied to the installation of the Energy Conserving Automatic Light Output System in the James E. Forrestal Building, a Federally owned building located on Independence Avenue, S. W. and newly designated as the headquarters building for the U.S. Department of Energy.

These calculations are purely illustrative in nature, as the realized costs and benefits of the installed system needs to be empirically determined. It must be emphasized however, that where estimates have been made the figures used are on the conservative side—tending to underestimate the economic benefits. For example, no inflation or related increase in the real cost of electricity is included.

Furthermore, these calculations consider only the "private" or internal benefits accruing from the installation of the system. The analysis would yield the same results if done for a privately owned building of the same size and with the same lighting equipment.

The Forrestal Building comprises 1,230,000 square feet gross and 1,192,105 square feet of net office space. Lighting is supplied primarily, almost exclusively, by standard four lamp, 40 watt/lamp fluorescent fixtures with ballasts. There are approximately 20,000 such fixtures in the building.[11]

It is interesting to note that at 2.6 We/sq. ft. this building is significantly "over designed" when compared to U.S. average commercial lighting demand of 2.0 We/sq. ft.; particularly so for a building with large amounts of exterior glass.

Using a figure of 184 We per fixture, including ballast loss, yields 3,680 kw of lighting demand. Assuming 252 hrs./month of operation (=21 days/month x 12 hrs./day) we then estimate current energy usage at 927,360 kwh per month for fluorescent lighting of the Forrestal Building.

Costs of retrofitting the existing fixtures with the ECALO System are estimated at $40.00 per fixture including installation. This figure is subject to some revision depending upon the size of production runs, location of automatic feedback devices, etc. It should be noted that initial installation costs, with the System replacing conventional ballasts in new construction, would be less. For this analysis, however, the assumed costs are $800,000.

Dollar savings in billed electricity will take two forms: reductions in the number of kilowatt-hours billed (the Energy Charge) during all months of the year; and a reduction during the summer months of the Demand Charge—billed at the maximum demand recorded during each month.

Conservative estimates were made of the ECALO System's potential lighting energy savings during PEPCO's on-peak (June–October) period of 35% and off-peak (November–May) period of 30%. An air conditioning energy savings factor of 50% of lighting energy saved, and an added heating energy factor of 40% of lighting energy saved were also assumed. Detailed calculations and assumptions are appended to this analysis,[12] but in summary the estimated savings are as follows:

Peak lighting energy savings	$68,500
Air conditioning energy savings	27,400
Reduced demand charges	43,300
Off-peak lighting energy savings	71,300
Additional heating energy costs	(20,400)
Annual electricity cost reductions	190,400

Four measures are most often used to evaluate investment projects. In this example, the $800,000 cost of acquisition and installation of the ECALO System in the Forrestal Building would rate favorably under all four measures:

1. Pay-back period: the period of time necessary to recover an initial investment.
   = $800,000 ÷ $190,000/year = 4.21 years
2. Benefit/Cost Ratio: the ratio of the discounted (here using 8%/year) benefits to the costs. (Assume a 20-year system life.)
   = $1,865,400 ÷ $800,000 = 2.33
3. Net Present Value: the discounted stream of ben[illegible]
   = $1,865,400 − $800,000 = $1,065,400
4. Internal Rate of Return: that rate of discount which sets the discounted stream of benefits net of costs equal to zero.

$$0 = \sum_{t=1}^{20} \frac{(\$190{,}000)t/ - \$800{,}000}{(1+r)t}$$

r=23.4

Conclusion

This analysis has examined the potential sources of energy savings realizable from the installation of the Energy Conserving Automatic Light Output System developed by Controlled Environment Systems, Inc. Using the fluorescent lighting system of the Forrestal Building as an example, calculations show that this is a highly cost effective system, regardless of the investment criteria used.

Calculation and Assumptions: A. On Peak (June-October).—

1. Net lighting energy savings of 35%
   = .35 (927,360)
   = 324,576 kwh per month
   @ 4.227¢/kwh (=2.777+1,450 fuel adjustment)
   = $13,719/month × five months = $68,599
2. Net Air Conditioning Energy Savings
   = 50% of lighting energy savings
   = $6,860/month × four months (assumed) = $27,440
3. Demand Charge Reduction of 60% of Peak Lighting (40% for lights, 20% for AC)
   = (3,680 kw) (.6)
   = 2,208
   @ $4.91/kw
   = $10,841/month × four months = $43,365

Calculations and Assumptions: B. Off-Peak (November-May).—

1. Net lighting energy savings of 30%
   = .30 (927,360)
   = 278,208 kwh
   @ 3.663¢/kwh (=2.213+1.450 fuel adj.)
   = $10,190/month × seven months = $71,330
2. Additional Heating Energy of 40% off-peak lighting savings
   = (.4) ($10,190)
   = $4,076 × five months = $20,380

Annualized savings

Direct summer lights	$68,599
A/C	27,440
Demand charge	43,365
Winter lights	71,330
Added heat	−20,380
Total	190,354

It must be emphasized that this example excluded any social benefits accruing from the system and assumed the retrofitting of existing lighting fixtures. An analysis of new construction utilizing the ECALO System and/or including all benefits would undoubtedly show higher returns to the investment. Similarly, allowing for increased real future increases in the billed price of electricity and/or time-of-day peak load pricing would increase the benefits of the system beyond those shown.

FOOTNOTES

[1] Estimated U.S. energy consumption = 74×10^{15} Btus. (74.10^{15}) (.05) (.66) (.4) ÷ (5.8×10^{6}) Btus/Bbl = (168.4) (10^{6}) Bbls.

[2] *Efficient Electricity Use*, Electric Power Research Institute, (EPRI EC–127) p. 531.

[3] Ibid. p. 664.

[4] Ibid. p. 505.

[5] *Washington Post;* October 19, 1977, p. B1.

[6] cf. *Efficient Electricity Use*, p. 484.

[7] See for example "Looking for More Lumens-Per-Watt", *Washington Post*, August 29, 1977, p. D9.

[8] *Efficient Electricity Use*, op. cit., p. 484.

[9] Ibid. p. 659.

[10] It must also be noted that many utilities are moving toward "time-of-day" peak load [illegible] schedule on July 8, 1977 although, if approved, its implementation would await proper meter installations. Should such rates be adopted, the benefits of ECALO would increase.

[11] These data were supplied via a telephone conversation with Mr. James Austin, Building Manager (PBS, GSA) of the Forrestal Building.

[12] Rates and charges taken from PEPCO General Service Schedule "GS" for the District of Columbia—effective March 1, 1977.

[13] 1977 PEPCO installed capacity is 5013 MWE (reported 10/25/77) via telephone conversation with Mr. Templeton, 872–2201.

Mr. CURTIS. Mr. President, I also ask unanimous consent that the statement of the distinguished Senator from Wyoming (Mr. HANSEN) and the statement of the distinguished Senator from New York (Mr. JAVITS) on this subject be printed in the RECORD at this point as if delivered.

The PRESIDING OFFICER. Without objection, it is so ordered.

● Mr. HANSEN. Dr. Henry Kelley with the Office of Technology Assessment has performed his own calculations and feels Don Widmayer has been very reasonable in his energy-saving estimates. Dr. Kelley perceives the key breakthrough of the system is its ability to automatically adjust the light output for fluorescent bulbs in much the same way as we dim chandeliers or other incandescent lights in our homes.

I agree with Senators CURTIS and JAVITS that this system deserves serious attention. If every Government building in Washington, D.C., were to install the ECALO light system, the risk of brownouts during the summer months could be substantially reduced since it is calculated that the peak power demand would diminish by 1½ percent.●

● Mr. JAVITS. Senator CURTIS, the lighting system you describe was demonstrated by its developer, Don Widmayer, in a Senate office room Thursday, February 23 before legislative assistants to Senators serving on the Energy and Finance Committees.

A special watt measuring meter showed that nearly 50 percent less energy was consumed by the fluorescent unit as sunlight entered the room. When the blinds were then shut, the light automatically increased in intensity to maintain a constant level of light in the room.

Mr. Widmayer's device is small and simple to install, but the concept is very innovative. Presently, ERDA is experimenting with high-frequency ballasts which can conserve 10 percent of energy utilized by lighting. However, there is a problem with high-frequency ballasts because of the interference they cause in office telephone connections.

Certainly, the Controlled Environment Systems, Inc. device deserves prompt attention by ERDA due to the fact it conserves far more energy without disturbing telephone reception.

I concur with Senator CURTIS, and urge GSA and DOE to take a hard look at this new system by trying it on a temporary basis in a Government building.●